

The Polyp Prevention Trial II: Dietary Intervention Program and Participant Baseline Dietary Characteristics

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Abstract

The Polyp Prevention Trial (PPT) is a multicenter randomized controlled trial to evaluate whether a low-fat, high-dietary fiber, high-fruit and -vegetable eating pattern will reduce the recurrence of adenomatous polyps of the large bowel. Men and women who had one or more adenomas removed recently were randomized into either the intervention ($n = 1037$) or control ($n = 1042$) arms. Food frequency questionnaire data indicate that PPT participants at the beginning of the trial consumed 36.8% of total energy from fat, 9.7 g of dietary fiber/1000 kcal, and 3.8 daily servings of fruits and vegetables. Baseline dietary characteristics, including intake of fat, fiber, and fruits and vegetables, as well as other macro- and micronutrients, were similar in the two study groups. The intervention participants receive extensive dietary and behavioral counseling to achieve the PPT dietary goals of 20% of total energy from fat, 18 g/1000 kcal of dietary fiber, and 5-8 daily servings (depending on total caloric intake) of fruits and vegetables. Control participants do not receive such counseling and are expected to continue their usual intake. Dietary intake in both groups is monitored annually using a 4-day food record (also completed at 6 months by intervention participants only) and a food frequency questionnaire, with a 10% random sample of participants completing an annual unscheduled 24-h telephone recall. Blood specimens are drawn and analyzed annually for lipids

and carotenoids. This article provides details on the rationale and design of the PPT dietary intervention program and describes the participant baseline dietary intake data characteristics.

Introduction

Background. The PPT,³ a multicenter randomized trial, tests the effect of a low-fat, high-fiber, high-fruit and -vegetable eating plan on the recurrence of adenomatous polyps of the large bowel. The dietary intervention program for the PPT encourages participants to adopt an eating plan consisting of 20% of calories from fat, 18 g of dietary fiber/1000 kcal, and 5-8 serving of fruits and vegetables/day. During the 4 years participants are enrolled in the study, dietary data, health and lifestyle information, quality-of-life data, and blood specimens are collected annually. In years 1 and 4, colonoscopies are performed and polyps are removed. More complete details of the study design and rationale are reviewed in a companion paper (1). This paper describes the rationale for the specific dietary goals, reviews the design of the dietary intervention, and presents baseline dietary intake characteristics of participants.

Although the primary objective of the PPT is to determine whether dietary change affects adenoma recurrence, other important issues related to the nutrition intervention are examined, including: a) the efficacy of the intervention program in accomplishing these dietary changes; b) the relationship between specific dietary changes and blood biomarkers; and c) the association between dietary changes and health, lifestyle, and quality-of-life factors.

Other polyp trials are investigating the effects of dietary supplements, such as antioxidant vitamins (2-4), calcium (5), or fiber (6), on the recurrence of adenomatous polyps. Two groups are studying the effect of a low-fat diet plus a wheat bran supplement on adenoma recurrence (7, 8). No previous large bowel adenomatous recurrence trial, however, has attempted to modify the overall dietary pattern of participants by counseling them to simultaneously aim for three quantitative dietary goals and to maintain them over such a long period of time (4 years).

The PPT intervention aims to alter the overall dietary pattern, rather than merely change a single nutrient (as in a fiber-supplement or low-fat intervention). This is one of the first dietary intervention clinical trials to use such a multigoal intervention approach. Investigators are increasingly recognizing the need to examine combined rather than single dietary component modifications. First, existing data support the notion of a total-diet approach. Specifically, lower large bowel cancer risk is associated with each of the three factors (low-fat, high-fiber, high-fruit and high-vegetable), with the greatest risk

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² See appendix.

³ The abbreviations used are: PPT, Polyp Prevention Trial; NHANES II, Second National Health and Nutrition Examination Survey; FFQ, food frequency questionnaire; NCI, National Cancer Institute; 4DFR, 4-day food record.

reduction observed among those who consume optimal levels of all three factors (9). Intervention with a low-fat, high-fiber, high-fruit and -vegetable eating plan thus maximizes the likelihood of reducing polyp recurrence. Second, it is unlikely that a protective effect can be attributed to a single food group or nutrient. Research findings on the cancer-protective effect of plant-based foods (fruits, vegetables, and grains) are much more consistent than those for vitamins or fiber supplements (10). The evidence suggests the existence of multiple protective factors in whole foods that may not be obtainable from supplements. Finally, with the exception of formula diets used in metabolic ward studies, changing a single component in the diet, such as fat, also changes multiple other dietary components, such as the amount of fruits and vegetables, fiber, and carbohydrates. The PPT intervention thus investigates the effects of a dietary pattern change.

Rationale for Dietary Goals

The specific level for each of the three PPT dietary goals was based on the following four factors: *a*) intake anticipated at baseline and maintained in the controls for the duration of the trial; *b*) feasibility of achieving the target level; *c*) safety associated with the target level of intake; and *d*) the level suggestive of cancer risk reduction in epidemiological studies.

Fat Goal. During the PPT planning phase in 1990, the percentage of calories from fat in the United States was estimated to be between 35 and 37% based on 24-h recalls in NHANES II (Ref. 11). National recommendations to reduce fat to 30% or less of energy should reduce fat intake further in the general population (12, 13). The feasibility of reducing fat intake to approximately 20% of calories has been demonstrated in several studies (14–16), and there is no evidence that this level of fat intake has any adverse effects. It is estimated that a 50% reduction in United States per capita fat intake (from 40% to 20% of calories) reduces colon cancer risk among individuals ages 55–69 by 60% among women and by 80% among men (17). These findings suggest that a reduction to 20% of calories from fat should result in a significant, measurable decrease in risk. Therefore, a reduction in fat intake to 20% of calories was chosen as both feasible and adequate to ensure a difference between the intervention and control group adequate. Only a few colon cancer studies before 1990 reported risks relative to type of fatty acid (18–20). Therefore, the PPT intervention focuses on reduction in total fat without selective reduction in specific types of fat.

Fiber Goal. National nutrition survey data from NHANES II suggests that dietary fiber intake in the United States to be approximately 11.1 g/day or 6 g/1000 kcal/day (21). The NCI recommendation to increase fiber to a minimum of 20 g/day (12) was expected to result in a modest increase in fiber intake. Increasing dietary fiber intake from foods up to a level of 60 g has been demonstrated to be feasible, well tolerated, and safe (22, 23). Although one case-control study shows protection for an intake of dietary fiber above 24 g/day (9), few epidemiological studies of large bowel cancer provide data that allow estimation of the precise level of dietary fiber that would be required to reduce colon cancer risk. The trial target of 18 g/1000 kcal (or an average intake of 35 g/day) was established because it is feasible, should provide adequate difference between intervention and control groups, and is associated with reduced colorectal cancer risk in the epidemiological literature.

The PPT intervention eating plan encourages participants to increase fiber from a variety of food sources. Approximately one-half of the dietary fiber intake is expected to be derived

from fruits and vegetables and the remainder from cereal grain products. Achieving a specific level of fiber from each of these sources, however, is not an intervention goal.

Fruit and Vegetable Goal. During the planning of the PPT, only 9% of the United States adult population consumed 3 or more servings of vegetables and 2 or more servings of fruit per day (24). Mean intake was 1.8 servings of vegetables and 1.1 servings of fruits and fruit juice (24). Since the 1980s, the United States Department of Agriculture and the Department of Health and Human Services Dietary Guidelines for Americans have recommended 2–3 daily servings of fruits and 3–5 daily servings of vegetables (25). Similarly, both the Surgeon General's Report (10) and the Diet and Health Report (13) recommend increased fruit and vegetable consumption for chronic disease prevention. Based on these recommendations and associated media campaigns, it is anticipated that during the course of the trial fruit and vegetable intake in the United States population will increase to approximately 3 to 4 servings/day. Although epidemiological studies show a fairly consistent inverse relation between fruit and vegetable intake and colorectal cancer, studies before 1990 did not report the quantitative level of total fruit and vegetable intake associated with reduced large bowel cancer risk, but merely ranked individuals according to their fruit and vegetable intake. Thus, a minimum level of servings needed to confer protection against large bowel cancer is not known. Based in part on the general dietary recommendations that consumption of 5 or more servings of fruits and vegetables is necessary for maintaining good health, a (calorie-adjusted) target of 5–8 servings/day was selected. This target appears feasible and likely to ensure a substantial intake difference between intervention and control groups.

The trial goal is to increase consumption of a variety of fruits and vegetables, without emphasis on specific types of these foods. The number of servings of fruits and vegetables is adjusted for baseline caloric intake as follows: <1300 kcal, 5 servings; 1301–1700 kcal, 6 servings; 1701–2100 kcal, 7 servings; and >2100 kcal, 8 servings. Because of the larger body of evidence on the protective effect of vegetables compared to fruits for large bowel cancer (26), participants are counseled to consume a minimum of 3 servings of vegetables/day. For this trial, legumes and potatoes are considered vegetables, and juices are not counted toward the fruit and vegetable goal. Juices (which contain little fiber) are excluded to enhance the likelihood of achieving fiber goals and to avoid confusion in defining what drinks constitute juices.

To ensure a similar dietary pattern in both male and female intervention participants, all dietary goals were adjusted according to caloric intake. Dietary goals for fat, fiber, and fruits and vegetables are set for each participant based on his or her baseline caloric intake as measured by a FFQ. These goals are not modified during the course of the trial even if the participant's caloric intake changes. Weight loss is permitted, but not encouraged. Intervention participants are counseled to replace fat calories with increased consumption of fruit, vegetable, and grain products rather than reduce total caloric intake.

Dietary Intervention Program

The intervention program draws from the approach used in the feasibility phase of the Women's Health Trial (14) and integrates nutrition education and behavior modification techniques. The PPT intervention program incorporates four key elements: *a*) nutrition skills-building; *b*) behavior modification techniques; *c*) self-monitoring techniques; and *d*) standardized nutrition education and behavior modification materials.

Nutrition Skills Building. To modify eating patterns effectively, participants must learn about the dietary factors to be changed, as well as acquire the skills necessary to change eating habits. Therefore, one objective of the intervention program is to provide information about fat, fiber, and fruits and vegetables, including food sources of fat and fiber, as well as ways to lower fat and increase fiber and fruits and vegetables. Participants practice skills related to making the necessary changes, such as food-label reading, low-fat cooking, estimating portion sizes, and incorporating fruits and vegetables into a variety of dishes.

Behavior Modification Techniques. A number of studies suggest that knowledge alone is insufficient to make long-term lifestyle changes. Programs that combine educational strategies with behavior modification techniques have proven to be much more effective in promoting long-term dietary changes than programs using educational approaches alone (27–29). The PPT intervention program incorporates a wide variety of behavioral techniques, including situational management, pre-planning, reward systems, goal-setting, and problem-solving. The primary emphasis, however, is on cognitive factors that underlie behavior changes: how people view themselves, their world, and the changes they make. Numerous studies indicate that although cognitive factors are not the only pertinent factors, they are probably the most powerful elements in promoting successful behavior change (30–32). The PPT intervention program, therefore, draws from a cognitive philosophy summarized in the following concepts. First, dietary patterns are a matter of choice and individuals are most likely to maintain changes if they are held accountable for their dietary intake. Second, conceptualizing foods as good *versus* bad is unlikely to result in long-term change in diet. Finally, individuals are most likely to sustain behavior change when it is based on a personal commitment, when changes are perceived as feasible, and when they take responsibility for their changes.

Self-Monitoring Techniques. Studies indicate that self-monitoring of a target behavior increases the likelihood of adopting the behavior (33, 34). Dietary self-monitoring supports behavior change by providing valuable and timely feedback about eating patterns, promoting self-awareness, providing nutritionists with information to develop more targeted support and guidance, helping to develop a sense of personal accountability, measuring progress toward goal, and motivating participants. In the PPT, self-monitoring is used as an education tool for improving adherence. Intervention participants are encouraged to self-monitor intake of fat, fiber, and fruits and vegetables throughout the trial. Participants are asked to keep daily records of food intake for the first 6 weeks and for four typical days per week for the remainder of the first year. In years 2, 3, and 4, participants are asked to self-monitor for four typical days per month. Participants who wish to self-monitor more frequently are encouraged to do so. Initial self-monitoring is done using the Fat and Fiber Score Diary, a pocket-size diary for recording food intake, and a Fat and Fiber Guide, an alphabetic and food group listing of 1100 foods. This guide lists the amount of fat, fiber, fruit and vegetable servings, and calories for each of these foods. After the first 6 months of intervention, other tools are available to stimulate interest in maintaining self-monitoring and to reduce the time required. These latter tools include the Fat and Fiber MiniGuide, which contains only 225 commonly eaten foods in eight color-coded sections; Diary At-A-Glance, a personalized master list of frequently eaten foods; and In Record Time, which reduces math calculations involved in keeping diet records and emphasizes fat budgeting.

Table 1 Standardized intervention materials used by intervention participants in the PPT

Name	Content
Nutritionist's Manual	Nutrition policies & leaders' guidelines
Intervention Participant's Manual	51 modules plus handouts
Fat and Fiber Guide	Fat, fiber, and fruits & vegetables in 1100 foods
Self-Monitoring Tools	Four tools
Recipe Collection	200 recipes

Standardized Nutrition Materials. A list of the standardized materials used in the PPT intervention program is given in Table 1. The core of the intervention materials is the set of 51 counseling modules. In addition, recipes, multiple self-monitoring tools, and supplemental handouts are distributed to intervention participants. The intervention is delivered primarily through counseling sessions conducted with each participant. Spouses or food preparers are encouraged to attend sessions. In the first year, individual counseling sessions are conducted to focus on the specific needs of the individuals. In years 2–4, the intervention program is delivered primarily through group counseling sessions to provide additional social support and help maintain motivation. Sessions are held weekly for the first 6 weeks, biweekly for next 6 weeks, and monthly for the remainder of the first year. Bimonthly sessions are held in year 2 and quarterly sessions in years 3 and 4. To maintain close contact with the participants, nutritionists are required to have phone contacts with intervention participants in months counseling sessions are not held.

Participants are initially instructed to reduce fat, then replace fat calories with fruits and vegetables and, by week 6, to add high-fiber grains to their eating plan. In this way, fat calories are replaced by fruits, vegetables, and grains; the increase in dietary fiber is gradual. Table 2 lists the 51 intervention modules used in PPT. Modules in years 1 and 2 integrate both nutrition and behavior in each counseling session. The remainder of the modules are devoted to a single topic, and nutritionists can select any one or two modules for a counseling session based on participants' needs. The six Fat Alert modules are delivered any time after year 1 to target specific high-fat eating patterns. Leaders' guidelines were developed for all modules to standardize the delivery of the intervention. Counseling sessions are conducted by registered dietitians trained in the PPT intervention by the Data and Nutrition Coordinating Center.

Control Group. The control group receives no dietary intervention counseling or materials because the strategy for this group is minimum interference with customary dietary intake. Dietary data necessary for appropriate comparison with the intervention group are collected. Participants in the control group attend one Clinical Center visit annually for dietary assessment and blood specimen collection.

Dietary Assessment

Many publications address the potential errors in estimating dietary intake and the pros and cons associated with various dietary assessment methods (35, 36). Because most measures of dietary intake rely on participant self-report, the possibility for inaccurate measurement exists regardless of the assessment tool (37). Therefore, the PPT uses three different dietary methods to estimate intake: modified Block/NCI FFQs (38), 4DFRs, and 24-h telephone recalls. At baseline and annually thereafter, FFQs and 4DFRs are obtained from all participants. At 6

Table 2 Dietary intervention counseling modules^{a, b, c}

Time distributed	Intervention Module
Year 1	Getting Acquainted
	Focusing on Fat
	Learning About Food Labels
	Following Up on Fat
	Eating Away From Home
	Focusing on Fruits and Vegetables
	Focusing on Fiber
	More on Fiber
	Keep on Moving
	Meal In Minutes
	Snacking Wisely
	Exploring the Vegetable Patch
	Desserts, Glorious Desserts
	Seafood... Making a Splash In Your Life
	Breakfast... Setting the Stage For Your Day
	Ethnic Foods and Seasonings
	Holiday Cheer and Celebrations
	Shortcuts
	1-Minute PPT Manager
Year 2	Grain and Bean It!
	Taking PPT on the Road
	Solutions and Substitutions
	Maintaining Your Motivation
	Keeping Your Balance
Years 3 & 4 ^{a, b}	Fresh Outlooks
	Pocket The Fat ^a
	Toss n' Turn Cooking ^a
	Seven Keys to Getting Motivated ^b
	What's Keeping You from Getting Motivated ^b
	Make It Snappy ^a
	Sizing Things Up ^a
	A Positive Attitude: What, Why, and How ^b
	Making and Refusing Requests ^b
	Emotional Support for Stress Management ^b
	Quick Relaxation Techniques ^b
	Communicate for Personal Power ^b
	A Big Fat Difference ^a
	Managing Daily Hassles ^b
	Visualizing and Affirming ^b
	Diet and Large Bowel Cancer—Facts Behind PPT ^a
	Separating Science Fact from Science Fiction ^a
	Good Fiber-a-tions ^a
	Score More with Fruit and Vegetables ^a
	A Table for One—or Two will Do ^a
	Life After the PPT ^a
Fat Alerts ^c	We've Got to Stop MEATing Like This
	Subtracting ADDED FATS
	Balancing Your FAT BUDGET
	Keeping Fat Down When OUT ON THE TOWN
	BAKED GOODS and Not-So-Goods
	"Moo"ving Toward Lower-Fat DAIRY CHOICES

^a The format and style of these materials were adapted from the Johnson & Johnson Health Management, Inc., Creative Units Courseware.

^b Modules purchased from Johnson & Johnson Health Management, Inc., 1989.

^c The six Fat Alert Modules are delivered any time after year 1.

months, an additional 4DFR is collected on all intervention participants to more closely monitor dietary change. Each year, 24-h telephone recalls are collected on 10% of both intervention and control participants.

Participants view instructional videos demonstrating food portion estimation and proper completion of PPT FFQs and 4DFRs. Although the FFQs and 4DFRs are self-administered,

both completed dietary assessments are reviewed with participants by nutrition staff trained and certified on all three dietary assessment tools. For each intervention participant, dietary assessments are conducted by nutrition staff not involved with that individual's intervention counseling.

The primary measure of dietary intake of the trial is the FFQ, which assesses intake during the past year. The Block/NCI FFQ (38) used in the PPT was modified to include more high-fiber foods, such as dried fruit, high-fiber cereals, and legumes. Low-fat and nonfat food items were also added to reflect changes in the marketplace. Additional questions were included to assess methods of cooking meat and caffeine intake. These FFQ modifications, combined with the nutritionist's review of completed dietary assessments, are intended to reduce the underestimation of calories frequently seen in FFQs (39).

4DFRs capture details of dietary habits not reflected in FFQs. Participants are instructed to keep 4DFRs on Sunday through Wednesday. All completed records are first reviewed with the participant by Clinical Center certified nutrition staff. The Nutrition Coordinating Center, University of Minnesota, then reviews all records for completeness. Twenty % of these reviewed records are coded and analyzed immediately, and the remainder are archived for future analyses. The 20% cohort selected for immediate analysis of 4DFRs was identified randomly with stratification by Clinical Center and gender. 4DFRs are analyzed for all nutrients, including types of fatty acids, and individual food items. Archived records can be analyzed on individuals, such as those with recurrent adenomas, to provide additional information on dietary intake.

Six months after randomization, telephone 24-h recalls are conducted at random on 10% of the participants each year. These recalls are conducted by Clinical Center nutrition staff on both weekends and weekdays. A potential strength of 24-h recalls is that they involve collection of unanticipated dietary data from the participant (40).

Using these three different types of dietary assessment methods, each with its own strengths and limitations, should increase the likelihood of obtaining accurate dietary data in this trial. The PPT also becomes a resource for future studies on comparison of these three dietary assessment tools. In addition, blood specimens are analyzed for total cholesterol (41), triglycerides (41), high-density lipoprotein-C (42), low-density lipoprotein-C (43), vitamins A and E, and individual serum carotenoids (Ref. 44; α -carotene, β -carotene, lutein, lycopene, and cryptoxanthin) on the same 20% cohort selected for 4DFR analysis. These data should be useful for evaluating biomarkers of dietary change.

Health and Lifestyle Data

At randomization and once annually throughout the trial, both the intervention and control groups complete a general health questionnaire to gather information that might be associated with dietary adherence and the development of adenomas. The health and lifestyle questionnaire includes questions on general demographic characteristics, current household composition, eating habits and food preparation, tobacco use, medical history (including family history of colorectal cancer), bowel habits, physical activity, and prescription and nonprescription drug use. Weight and height are measured at baseline, and weight is measured at each subsequent annual visit. A cohort of 200 intervention and 200 control participants also completes an additional questionnaire to obtain information on quality of life,

Table 3 Baseline intake of fat, fiber, and fruits and vegetables for PPT control and intervention participants^{a, b, c}

	Control ^a	Intervention
FFQ^b		
Fat, % calories	36.0 (0.23)	35.8 (0.22)
Fiber, g/1000 kcal	9.5 (0.12)	9.9 (0.12)
Fruits & vegetables, servings/day ^c	3.8 (0.05)	3.8 (0.05)
4DFR^d		
Fat, % calories	32.5 (0.47)	32.2 (0.44)
Fiber, g/1000 kcal	9.7 (0.21)	9.8 (0.21)
Fruits & vegetables, servings/day ^c	4.7 (0.15)	4.8 (0.25)

^a Values are presented as mean (SEM).^b Data derived from 380 female and 662 male control participants and 348 female and 689 male intervention participants; *n* = 1042 control and 1037 intervention.^c A serving is defined as follows: vegetables, 1/2 cup raw, canned, or cooked; 1 cup raw leafy, 1/2 cup legumes; or 1 medium. Fruits, 1/2 cup raw, canned, or cooked; 1/4 cup dried; or 1 medium (1 large = 1 1/2 servings; 1 small = 1/2 serving).^d Data derived from 69 female and 153 male control participants and 72 female and 151 male intervention participants; *n* = 222 control and 223 intervention.**Table 4** Baseline calorie and macronutrient intake for men and women^a

	Male <i>n</i> = 1351 ^b	Female <i>n</i> = 728
Calories, kcal	2094.2 (16.48)	1767.0 (19.64)
Protein, g	84.7 (0.66)	74.3 (0.86)
Protein, % calories	16.4 (0.07)	17.0 (0.11)
Fat, g	85.1 (0.89)	70.4 (1.08)
Fat, % calories	36.2 (0.19)	35.4 (1.08)
Carbohydrate, g	237.2 (2.09)	207.1 (2.54)
Carbohydrate, % calories	45.5 (0.21)	47.1 (0.29)
Fiber, g	18.5 (0.21)	17.4 (0.29)
Cholesterol, mg	284.3 (3.68)	219.9 (3.77)
Saturated fat, g	29.6 (0.34)	23.8 (0.39)
Monounsaturated fat, g	31.5 (0.34)	25.8 (0.41)
Polysaturated fat, g	15.1 (0.18)	13.4 (0.25)

^a All data are from the baseline FFQ.^b Values are presented as mean (SEM).

including self-perceived physical and emotional well-being and satisfaction with diet and self-care.

Baseline Dietary Characteristics

As indicated by FFQ and 4DFR data, control and intervention groups had similar baseline fat, fiber, and fruit and vegetable intake (Table 3). Numerous factors can contribute to slight discrepancies commonly observed in FFQ and 4DFR estimation of dietary intake (40). The intervention and control groups are also similar with respect to other nutrient and food group intake, dietary supplement use, and eating behaviors, such as meals eaten away from home, meals/day, and snacking (data not shown).

Baseline dietary data have been collected on 1351 men (mean age, 62) and 728 women (mean age, 60). Table 4 gives calorie and macronutrient intake by gender as estimated by FFQ. For men, these values are comparable to those reported in the recent NHANES III (45), except for fat. The NHANES III national survey, using 24-h recall data, reported 33.3% of calories from fat (80g/day) for men 60–69 years old. This value is similar to the 32.8% of calories from fat for PPT men estimated by 4DFR. Women in the PPT consume approximately 200 calories/day more than women 60–69 years in the NHANES III survey (45). After adjusting for caloric intake the nutrient values for women, given in Table 4, are also very

Table 5 Baseline intake of selected food groups^a

	Male <i>n</i> = 1351 ^b	Female <i>n</i> = 728
Fruits	1.3 (0.03)	1.4 (0.03)
Vegetables	2.4 (0.03)	2.5 (0.04)
Fruit juices	0.7 (0.02)	0.7 (0.02)
Legumes	0.16 (0.01)	0.14 (0.01)
Fiber cereals	0.5 (0.01)	0.5 (0.01)
Red meat	0.7 (0.01)	0.5 (0.01)
Fatty luncheon meat	0.3 (0.01)	0.2 (0.01)
Chicken/fish	0.6 (0.01)	0.6 (0.01)
Dairy products	1.1 (0.02)	1.3 (0.03)
Butter/margarine	1.0 (0.02)	1.1 (0.03)

^a All data are from the FFQ.^b Values are presented as mean servings/day (SEM).

similar to NHANES III, except for fat, which is 31.6% of calories (45).

The epidemiological literature suggests that a number of food groups might be related to large bowel cancer. Table 5 gives PPT baseline intake for some of these foods. PPT men and women consume approximately the same number of servings of these foods, although men consume approximately 300 calories/day more. Men consume slightly higher levels of red meat and fatty luncheon meat and slightly lower levels of dairy products and butter/margarine. These data are comparable to the 1987 NHIS survey for most food groups (46). The NHIS survey reported higher intake of butter/margarine (1.6 servings/day for males, 1.7 servings/day for females) and lower intake of chicken/fish (0.2 servings/day for both males and females) and fruits and vegetables (46). In the 1987 National Health Interview Survey, men and women consumed approximately 1 less serving/day of fruits and vegetables than did PPT participants (46). The more recent 1991 baseline survey for the NCI Five a Day Program reported 3.2 servings/day of fruits and vegetables for men and 4.2 servings/day for women of comparable age (47).

A variety of nutrient supplements, including vitamin E (2, 3, 4), vitamin C (2, 3, 4), calcium (5) and dietary fiber (6, 7, 8), have been evaluated as chemopreventive agents in other polyp clinical trials. PPT participants are not asked to refrain from taking dietary supplements. However, to ensure that these and other nutrient supplements will not confound results of the PPT dietary intervention, supplement use is monitored. Table 6 shows that a little over 30% of PPT participants take vitamin supplements. These levels agree with the 1980 and 1986 national surveys, which report that one in three American adults use dietary supplements (48). The slightly higher intake of dietary supplements in elderly women is well documented (49, 50). Nutrient values listed in Table 6 are quite similar to NHANES III for the B vitamins, folate and iron (51). Men in the PPT consume approximately 15% more dietary vitamin A, 40% more dietary vitamin C, and 10% less dietary vitamin E, and women consume about 35% more dietary vitamin A, 40% more dietary vitamin C, and 20% more dietary calcium than NHANES III (51). At baseline, women in the PPT exceed the recommended dietary allowance for all vitamins and minerals listed in Table 6, whereas men are below recommended dietary allowance levels for vitamin E (10 TE) and calcium (1200 mg; Ref. 52). Fiber supplement use is quite low in PPT and should not interfere with the ability of the trial to evaluate changes in dietary fiber intake.

Because various eating behaviors could affect dietary ad-

Table 6 Percent of participants at baseline consuming dietary supplements and their nutrient intake with and without supplements^a

	Percent consuming male ^b	Percent consuming female	Dietary intake, male	Total intake, male	Dietary intake, female	Total intake, female
Vitamin A, IU	31.5	36.3	9605 (146)	11,162 (172)	10,160 (239)	11,770 (274)
Vitamin C, mg	39.9	46.8	141.6 (2.08)	295.9 (10.88)	138.9 (2.81)	357.9 (18.88)
Vitamin E, mg α -TE	38.12	45.6	8.8 (0.08)	48.2 (2.99)	8.0 (0.11)	65.2 (5.37)
Thiamin, mg	31.2	36.4	1.6 (0.01)	2.9 (0.11)	1.4 (0.19)	3.2 (0.18)
Riboflavin, mg	32.0	37.5	2.1 (0.02)	3.3 (0.08)	1.9 (0.03)	3.5 (0.13)
Niacin, mg	32.0	37.5	23.3 (0.19)	36.0 (0.84)	19.9 (0.24)	36.6 (1.31)
Folate, mg ^c			323.4 (3.41)		292.4 (4.42)	
Calcium, mg	5.4	31.0	873.3 (11.47)	901.4 (12.36)	846.8 (16.60)	1083.5 (26.47)
Iron, mg	32.0	37.5	16.01 (0.14)	20.58 (0.26)	14.1 (0.02)	19.2 (0.36)
Fiber, g	10.7	14.3	18.5 (0.21)	18.9 (0.21)	17.4 (0.29)	18.0 (0.29)

^a All data are from the FFQ.^b Values are presented as mean (SEM).^c Folate supplement use is not estimated by the PPT FFQ.Table 7 Food shopping, preparation, and eating occasions for PPT participants at baseline^a

	Male, % ^b	Female, %
Primary, grocery shopper: self	28.4 (1.23)	80.4 (1.47)
Primary cook: self	21.4 (1.12)	85.7 (1.30)
Eat 3 meals/day	62.6 (1.32)	66.5 (1.75)
Eat 1 or 2 snacks/day	38.4 (1.32)	32.4 (1.73)
Eat 2-7 meals/week away from home	54.7 (1.35)	58.2 (1.83)

^a All data are from the Health and Lifestyle Questionnaire.^b Values presented as mean (SEM).

herence, participants were asked specific questions concerning food preparation, meal patterns, and restaurant eating. Baseline responses to these questions are summarized in Table 7. Women are the primary grocery shoppers (80.4%) and cooks (85.7%). Otherwise, there are few differences between male and female participants. The majority of participants eat three meals a day, have one or two snacks, and consume 2-7 meals/week away from home.

Discussion

The PPT intervention program is designed to address three specific areas that traditionally have been problematic in dietary intervention trials: *a*) poor adherence among intervention participants; *b*) "drop-in" or "contamination" among control participants, and *c*) inaccurate assessment of dietary intake.

Promoting Long-Term Adherence among Intervention Participants. The intervention group must make marked changes in usual eating patterns to meet PPT dietary goals. To sustain a substantial difference between control and intervention intake for the duration of the trial, it is necessary to take an aggressive approach to long-term adherence to the PPT eating plan. Even with intense counseling by PPT nutritionists, it is anticipated that the intervention dietary goals will be difficult to achieve and maintain over a long period of time (4 years). The PPT intervention program, which integrates both behavioral and nutrition education components, was designed to help participants make and maintain long-term changes. In addition, the intervention program is sensitive to the lifestyle characteristics of the participants. For example, because approximately 80% of male participants are not the primary cook or food shopper, they are encouraged to have the primary cook or shopper for the household attend both individual and group sessions. The intervention program also offers many suggestions for preparing

easy meals and/or meeting PPT dietary goals when eating out and snacking.

Progress toward dietary goals is continually monitored. This allows for constructive action to be taken when there is an indication that the intervention group falls short of its dietary goals. The intervention program is augmented as necessary to include more focus on specific areas to encourage intervention participants to meet their dietary goals.

Prevention of Drop-in or Contamination among Control Participants. Although it is anticipated that it will be difficult for control participants to approach the overall dietary goals achieved by the intervention group without the benefit of the intensive counseling program, control drop-in is an area of concern. First, control participants may be interested in making health-promoting dietary changes, given their interest in study participation. Drifts in the control group may be compounded by general changes in fat intake in the United States resulting from an increased interest in health and also the increased availability of a variety of reduced-fat food products. Similar concerns exist with regard to national campaigns promoting increased fruit and vegetable intake. To minimize potential control group contamination, the PPT control participants have no contact with trial nutritionists beyond the annual dietary assessment visit. Furthermore, intervention group activities are conducted separately from those involving the control participants.

Accuracy of Dietary Assessment. Because of the limitations of any one dietary assessment method, the PPT uses three separate methods of assessing intakes of various nutrients and food groups: the FFQ, which measures usual intake; the 4DFR, which records intake on specified days; and the 24-h recall, which obtains dietary data at unannounced times. To minimize bias in dietary assessment data, several procedures have been established. First, nutritionists who provide counseling for a participant cannot perform dietary assessment activities for that participant. Second, participants do not receive written or verbal feedback from their completed dietary assessments. Finally, nutritionists do not receive individual dietary assessment data on participants. Because some feedback on individuals is important to help participants change their eating patterns, participant self-monitoring information and group (rather than individualized) dietary assessment data are used to assist participants and nutritionists in meeting PPT dietary goals. Despite the efforts to ensure unbiased and accurate reporting of dietary intake, all three assessment methods rely on self-reports. Therefore, potential blood biomarkers are monitored throughout the

trial and compared to data collected from the various dietary assessment tools.

Conclusion. Large-scale dietary intervention control trials are major scientific undertakings requiring extensive resources and personnel. Problems common to these trials include lack of adherence, inaccurate estimation of dietary intake, and contamination of the control group. The PPT was designed to address these problems and, thus, to provide data necessary to evaluate whether dietary modification influences risk of large bowel malignancy, one of the leading causes of cancer death in westernized countries.

Appendix

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References

- Schatzkin, A., Lanza, E., Freedman, L. S., Tangrea, J., Cooper, M. R., Marshall, J. R., Murphy, P. Selby, J. V., Shike, M., Schade, R. R., Burt, R. W., Kikendall, J. W., Cahill, J., and the PPT Study Group. The Polyp Prevention Trial: rationale, design, recruitment, and participant characteristics. *Cancer Epidemiol., Biomarkers & Prev.*, 5: 375-383, 1996.
- McKeown, G. E., Holloway, C., Jazmaji, V., See, E. B., Dion, P., Bruce, W. R. A randomized trial of vitamins C and E in the prevention of recurrence of colorectal polyps. *Cancer Res.*, 8: 4701-4705, 1988.
- Roncucci, L., Di Donato, P., Carati, L., Ferrari, A., Perini, M., Bertoni, G., Bedogni, G., Paris, B., Svanoni, F., Girola, M., and Ponz de Leon, M. Antioxidant vitamins or lactulose for the prevention of the recurrence of colorectal adenomas. *Dis. Colon Rectum*, 36: 227-234, 1993.
- Greenberg, E. R., Baron, J. A., Tosteson, T. D., Freeman, D. H., Beck, G. J., Bond, J. H., Colacchio, T. A., Collier, J. A., Frankl, H. D., Haile, R. W., Mandel, J. S., Nierenberg, D. W., Rothstein, R., Snover, D. C., Stevens, M. M., Summers, R. W., and Van Stolk, R. U. A clinical trial of antioxidant vitamins to prevent colorectal adenoma. *N. Engl. J. Med.*, 331: 141-147, 1994.
- Vargas, P. A., and Alberts, D. S. Primary prevention of colorectal cancer through dietary modification. *Cancer (Phila.)*, 70: 1229-1235, 1992.
- Hill, M. J. ECP trial of fiber in precancerous lesions of the large bowel. In: D. Kritchevsky and C. Bonfield (eds.), *Dietary Fiber in Health and Disease*, pp. 226-234. Minnesota: Eagan Press, 1995.
- McKeown, G. E., See, E. B., Bruce, W. R., and Jazmaji, V. The Toronto Polyp Prevention Group. A randomized trial of a low fat, high fiber diet in the recurrence of colorectal polyps. *J. Clin. Epidemiol.*, 47: 525-536, 1994.
- MacLennan, R., Macrae, F., Bain, C., Battistutta, D., and Wahlqvist, M., APPP Investigators. A randomized controlled trial of fat, fibre and β -carotene to prevent colorectal adenomas: The Australian Polyp Prevention Project. *J. Natl. Cancer Inst.*, 87: 1760-1766, 1995.
- Kune, S., Kune, G. A., and Watson, L. F. Case-control study of dietary etiological factors: the Melbourne colorectal cancer study. *Nutr. Cancer*, 9: 21-42, 1987.
- United States Department of Health and Human Services, Public Health Service. Surgeon General's Report on Nutrition and Health, pp. 177-247. Washington, DC: United States Government Printing Office, 1988.
- Block, G., Rosenberger, B. A., and Patterson, M. A. Calories, fat and cholesterol: Intake patterns in the U.S. by race, sex and age. *Am. J. Public Health*, 87: 1150-1156, 1988.
- Butrum, R. R., Clifford, C. K., and Lanza, E. NCI dietary guidelines: rationale. *Am. J. Clin. Nutr.*, 48: 888-895, 1988.
- Committee on Diet and Health, Food and Nutrition Board, Commission on Life Sciences. National Research Council. Diet and health: implications for reducing chronic disease risk, pp. 665-710. Washington, DC: National Academy Press, 1989.
- Insull, W., Jr., Henderson, M., Prentice, R. L., Thompson, O. J., Clifford, C., Goldman, S., Gorbach, S., Moskowitz, M., Thompson, R., and Woods, M. Results of a randomized feasibility study of a low fat diet. *Arch. Intern. Med.*, 150: 421-427, 1990.
- Chlebowski, R. T., Nixon, D. W., Blackburn, G. L., Jochimsen, P., Scaloni, E. F., Insull, W., Jr., Buzzard, I. M., Elashoff, R., Butrum, R., and Wynder, E. A breast cancer nutrition adjuvant study (NAS): protocol design and initial patient adherence. *Breast Cancer Res. Treat.*, 10: 21-29, 1987.
- Boyd, N. F., Cousins, M., and Kriukov, V. A randomized controlled trial of dietary fat reduction: the retention of subjects and the characteristics of drop outs. *J. Clin. Epidemiol.*, 45: 31-35, 1992.
- Prentice, R. L., and Sheppard, L. Dietary fat and cancer: consistency of the epidemiologic data, and disease prevention that may follow from a practical reduction in fat consumption. *Cancer Causes & Control*, 1: 81-97, 1990.
- Jain, M., Cook, G. M., Davis, F. G., Grace, M. G., Hove, G. R., and Miller, A. B. A case-control study of diet and colorectal cancer. *Int. J. Cancer*, 26: 319-322, 1980.
- Philips, R. L. The role of lifestyle and dietary habits in risk of cancer among Seventh-day Adventists. *Cancer Res.*, 35: 3513-3522, 1975.
- West, D. W., Slattery, M. L., Robison, L. M., Schuman, K. L., Ford, M. H., Mahoney, A. W., Lyon, J. L., and Sorenson, J. L. Dietary intake and colon cancer: anatomic site-specific associations. *Am. J. Epidemiol.*, 130: 883-894, 1989.
- Lanza, E., Jones, D. Y., Block, G., and Kessler, L. Dietary fiber intake in the U.S. population. *Am. J. Clin. Nutr.*, 46: 790-797, 1987.
- Kelsay, J. L., Jacob, R. A., and Prather, E. S. Effect of fiber from fruits and vegetables on metabolic responses of human subjects. *Am. J. Clin. Nutr.*, 32: 2307-2312, 1979.
- Anderson, J. W., and Abayomi, O. A. Treatment of diabetes with high fiber diets. In: G. A. Spiller (ed.), *CRC Handbook of Dietary Fiber in Human Nutrition*, pp. 443-470. Boca Raton, FL: CRC Press, Inc., 1992.
- Patterson, B. H., Block, G., Rosenberger, W. F., Pee, D., and Kahle, L. L. Fruit and vegetables in the American diet: data from the NHANES II survey. *Am. J. Public Health*, 80: 1443-1449, 1990.
- United States Department of Agriculture, United States Department of Health and Human Services. Nutrition and Your Health. Dietary Guidelines for Americans, pp. 1-27. Washington, DC: United States Government Printing Office, 1981.
- Steinmetz, K. A., and Potter, J. D. Vegetables, fruits, and cancer epidemiology. *Cancer Causes & Control*, 2: 325-357, 1991.
- Stunkard, A. J. Environment and obesity: recent advances in our understanding of the regulation of food intake in man. *Fed. Proc.*, 27: 1367-1373, 1968.

28. Stuart, R. B. Behavioral control of overeating. *Behav. Res. Ther.*, 5: 357-365, 1967.
29. Wadden, T. A., Stunkard, A. J. Controlled trial of a very low-calorie diet, behavior therapy, and their contribution in the treatment of obesity. *J. Consult. Clin. Psychol.*, 54: 482-488, 1986.
30. Strecher, V. J., DeVellis, B. M., Becker, M. H., and Rosentock, I. M. The role of self-efficacy in achieving health behavior change. *Health Education Quarterly*, 13: 73-92, 1986.
31. Janz, N. K., and Becker, M. H. The health belief model: a decade later. *Health Education Quarterly*, 11: 1-47, 1984.
32. Bandura, A. Self-efficacy: toward a unifying theory of behavioral change. *Psychol. Rev.*, 84: 191-215, 1977.
33. Streit, K. J., Stevens, N. H., Stevens, V. J., and Rossner, J. Food records: predictor and modifier of weight change in a long-term weight loss program. *J. Am. Diet. Assoc.*, 97: 213-216, 1991.
34. Madsen, J., Sallis, J. F., Rupp, J. W., Senn, K. L., Patterson, T. L., Atkins, C. J., and Nadar, P. R. Relationship between self-monitoring of diet and exercise change and subsequent risk factor changes in children and adults. *Patient Educ. Couns.*, 21: 61-69, 1993.
35. Buzzard, M. Rationale for an international conference series on dietary assessment methods. *Am. J. Clin. Nutr.*, 59(Suppl.): 143s-145s, 1994.
36. Bingham, S. A. Current intake. In: B. M. Margetts and M. Nelson (eds.), *Design Concepts in Nutritional Epidemiology*, pp. 153-191. New York: Oxford University Press, 1991.
37. Beaton, G. H. Approaches to analysis of dietary data: relationship between planned analyses and choice of methodology. *Am. J. Clin. Nutr.*, 59(Suppl.): 253s-261s, 1994.
38. Block, G., Woods, M., Potosky, A., and Clifford, C. Validation of a self-administered diet history questionnaire using multiple diet records. *J. Clin. Epidemiol.*, 43: 1327-1335, 1990.
39. Willett, W. C., Sampson, L., Stampfer, M. J., Rosner, B., Bain, C., Witschi, J., Hennekens, C. H., and Spizer, F. E. Reproducibility and validity of a semiquantitative food frequency questionnaire. *Am. J. Epidemiol.*, 122: 51-65, 1985.
40. Thompson, F. E., and Byers, T. Dietary assessment resource manual. American Institute of Nutrition. *J. Nutr.*, 124(Suppl.): 2245s-2317s, 1994.
41. Lipids Research Clinics Manual of Laboratory Operations. Lipid and Lipoprotein analysis. Department of Health, Education and Welfare Publ. No. (NIH) 75-628, May 1974, Revised 1982. Washington, DC: United States Government Printing Office.
42. Bachorik, P. S., Walker, R. E., and Virgil, D. G. High-density-lipoprotein cholesterol in heparin-MnCl₂ supernates determined with Dow enzymatic method after precipitation of Mn²⁺ with HCO₃. *Clin. Chem.*, 30: 839-842, 1984.
43. Friedewald, W. T., Levy, B. B., Brodie, B. B., and Kendall, F. E. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of preparative ultracentrifuge. *Clin. Chem.*, 18: 499-502, 1972.
44. Sowell, A., Huff, D. L., Yeager, P. R., Caudill, S. P., and Gunter, E. R. Retinol, α -tocopherol, lutein/zeaxanthin, β -cryptoxanthin, lycopene, α -carotene, trans- β -carotene, and four retinyl esters in serum determined simultaneously by reversed phase HPLC with multiwavelength detection. *Clin. Chem.*, 44: 411-416, 1994.
45. Briefel, R., McDowell, M. A., Alaimo, K., Bischof, A. M., Caughman, C. R., Carroll, M. D., Loria, C. M., and Johnson, C. L. Total energy intake of the U.S. population: the Third National Health and Nutrition Examination Survey, 1988-1991. *Am. J. Clin. Nutr.*, 255: 1-23, 1994.
46. Patterson, B. H., Harlan, L. C., Block, G., and Kahle, L. Food choices of whites, blacks and Hispanics: data from the 1987 National Health Interview Survey. *Nutr. Cancer*, 23: 105-119, 1995.
47. Subar, A. F., Heimendinger, J., Patterson, B., Krebs-Smith, S. M., Pivonka, E., and Kessler, R. Fruit and vegetable intake in the U.S.: the baseline survey of the Five A Day for Better Health Program. *Am. J. Health Promotion*, 9: 352-360, 1995.
48. Interagency Board for Nutrition Monitoring and Related Research. Nutrition Monitoring in the United States. Department of Health and Human Services Publ. No. (PHS) 93-1255-2, pp.49-50. Washington, DC: United States Government Printing Office, 1993.
49. Hartz, S. C., and Blumberg, J. Use of vitamin and mineral supplements by the elderly. *J. Am. Coll. Nutr. (Phila.)*, 5: 130-136, 1986.
50. Moss, A. J., Levy, A. S., Kim, I., and Park, Y. K. Use of vitamin and mineral supplements in the United States: current users, types of products, and nutrients. In: *Advance Data from Vital Health Statistics*, Vol. 174, pp. 1-20. Hyattsville, MD: National Center for Health Statistics, 1989.
51. Alaimo, K., McDowell, M. A., Briefel, R., Bischof, A. M., Caughman, C. R., Loria, C. M., and Johnson, C. L. Dietary intakes of vitamins, minerals, and fiber of persons ages 2 months and over in the United States: Third National Health and Nutrition Examination Survey, Phase 1, 1988-1991. In: *Advance Data from Vital Health Statistics*, Vol. 258, pp. 1-25. Hyattsville, MD: National Center for Health Statistics, 1994.
52. Food and Nutrition Board Commission on Life Sciences, National Research Council. Recommended Dietary Allowances, 10th Edition, p. 285. Washington, DC: National Academy Press, 1989.